EWEA CREYAP benchmark exercises: summary for offshore wind farm cases

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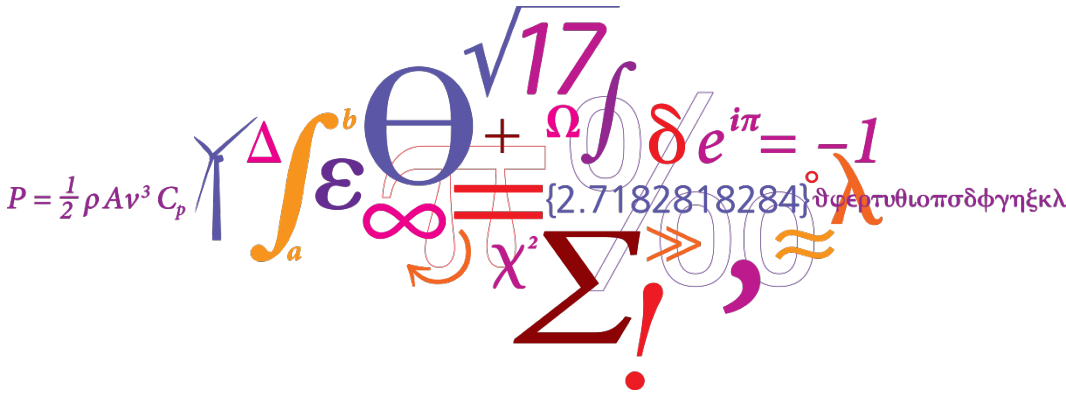
Niels G Mortensen, Morten Nielsen & Hans E Jørgensen

Wind Energy Denmark 2015



DTU Wind Energy
Department of Wind Energy

Acknowledgements

- RES Ltd. for Gwynt y Môr data pack
- DONG Energy Wind Power A/S for Barrow data
- Dong Energy, Iberdrola and Crown Estate for Shell Flats wind data and other information.
- 60 teams from 13 countries; thanks for making the comparison and presentations possible!
- EWEA for arranging Offshore CREYAP Part 1+2, thanks to Tim Robinson and his team.

Comparison of Resource and Energy Yield Assessment Procedures

EWEA CREYAP concept

- Industry benchmarking
- In-house training and R&D
- Identification of R&D issues

Three issues today

- Wakes and wake modelling
- Yield assessment uncertainties
- Modelled vs observed yields

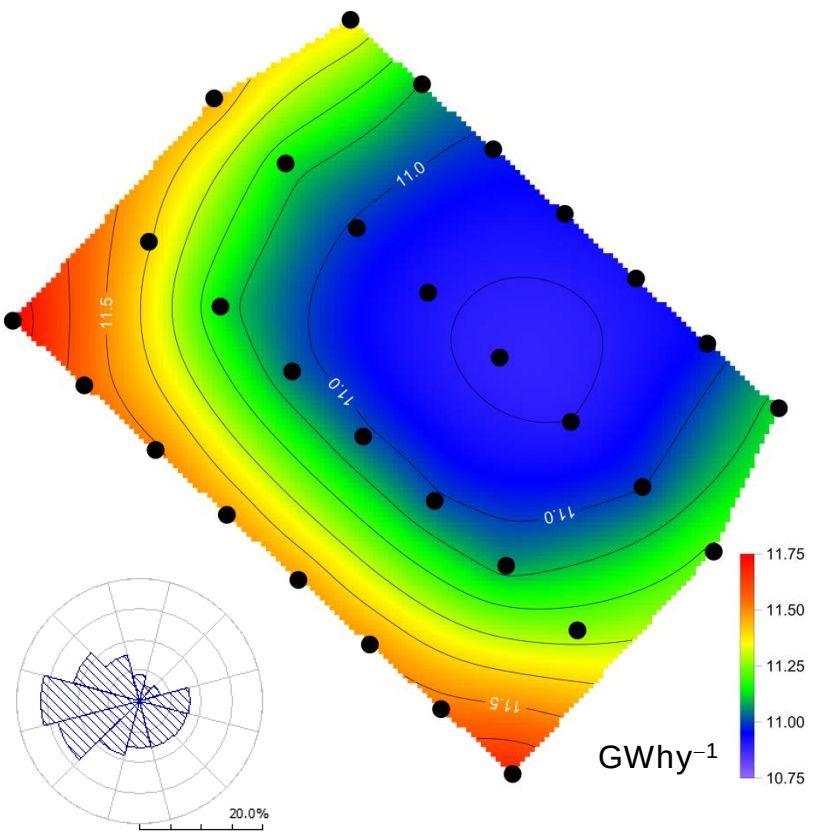
CREYAP history

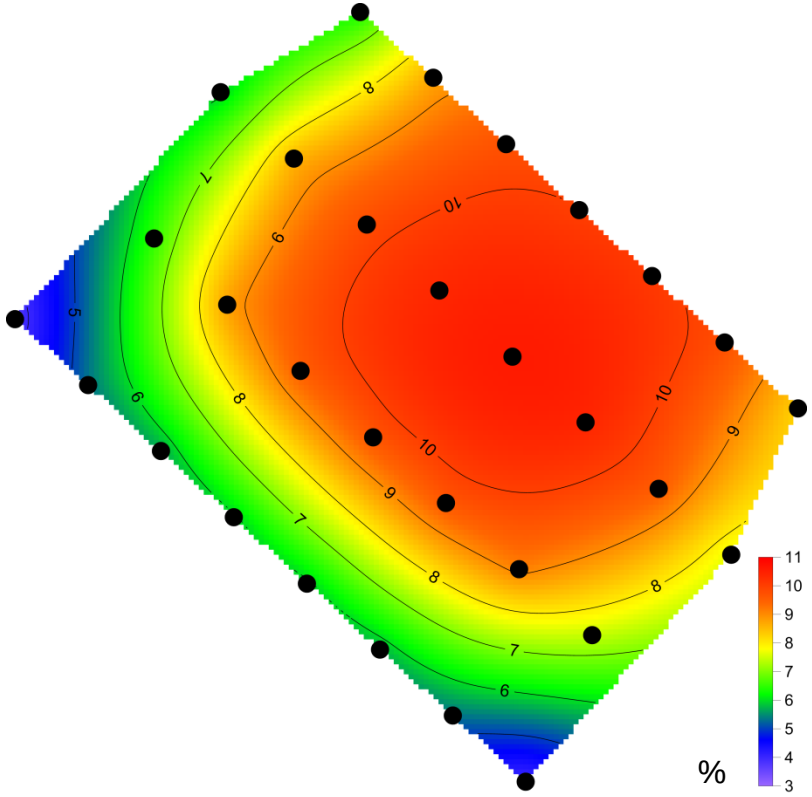
- Onshore Part 1, Bruxelles 2011
  - Scotland W, 14 × 2 MW (28 MW)
- Onshore Part 2, Dublin 2013
  - Scotland E, 22 × 1.3 MW (29 MW)
- Offshore Part 1, Frankfurt 2013
  - Gwynt y Môr, 160 × 3.6 (576 MW)
- Offshore Part 2, Helsinki 2015
  - Barrow, 30 × 3 MW (90 MW)

Summary

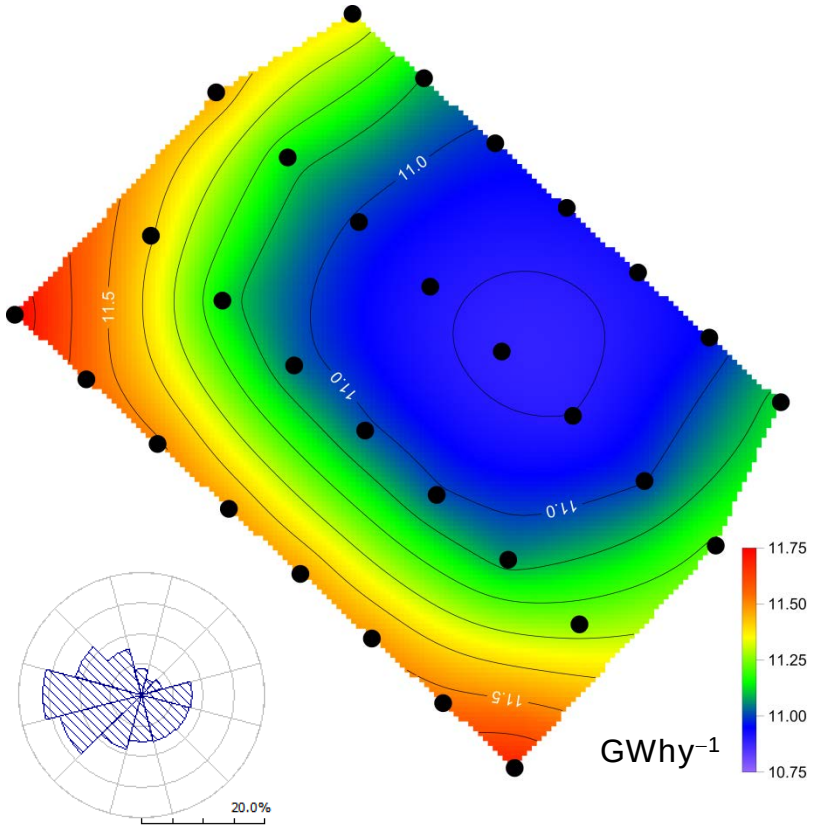
- 157 submissions from 27 countries
  - 97 for onshore
  - 60 for offshore

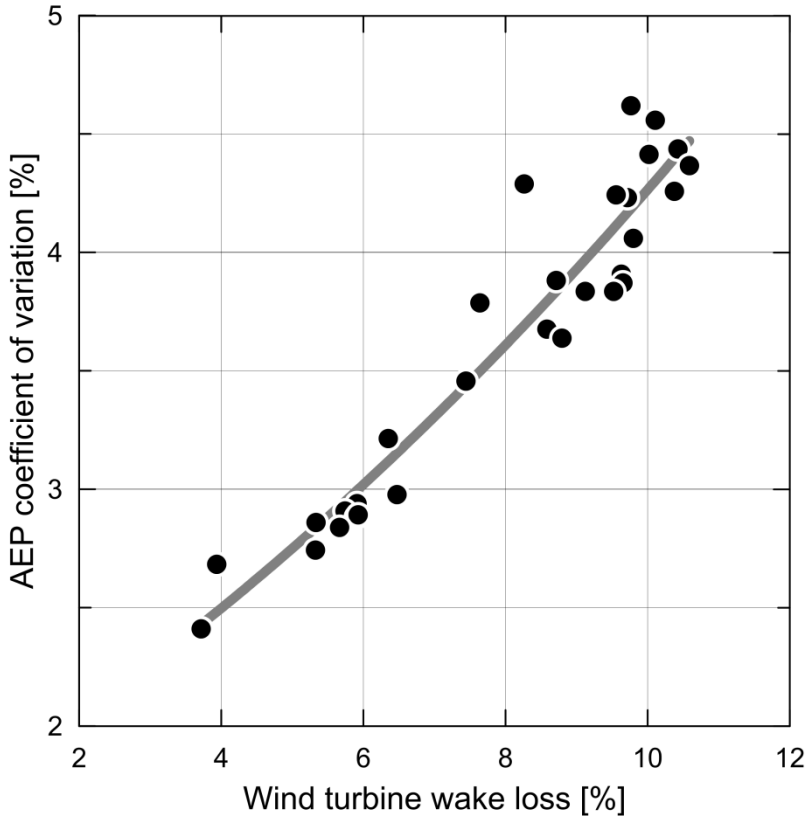
Barrow estimated turbine yields and wake effects



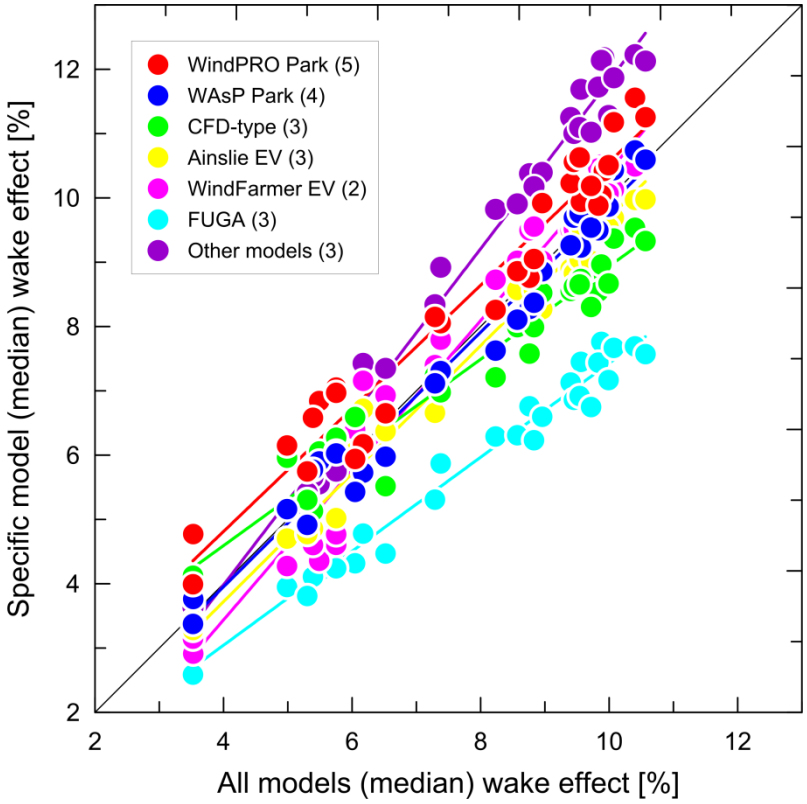


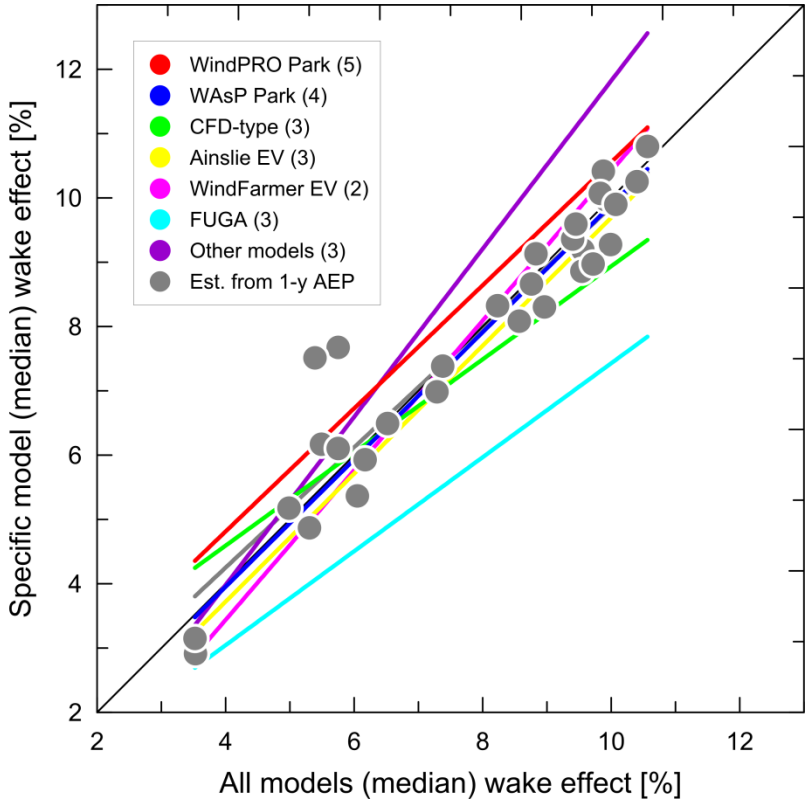
Barrow estimated turbine yields and spread of results





Barrow wind farm (only) – which wake model is best?



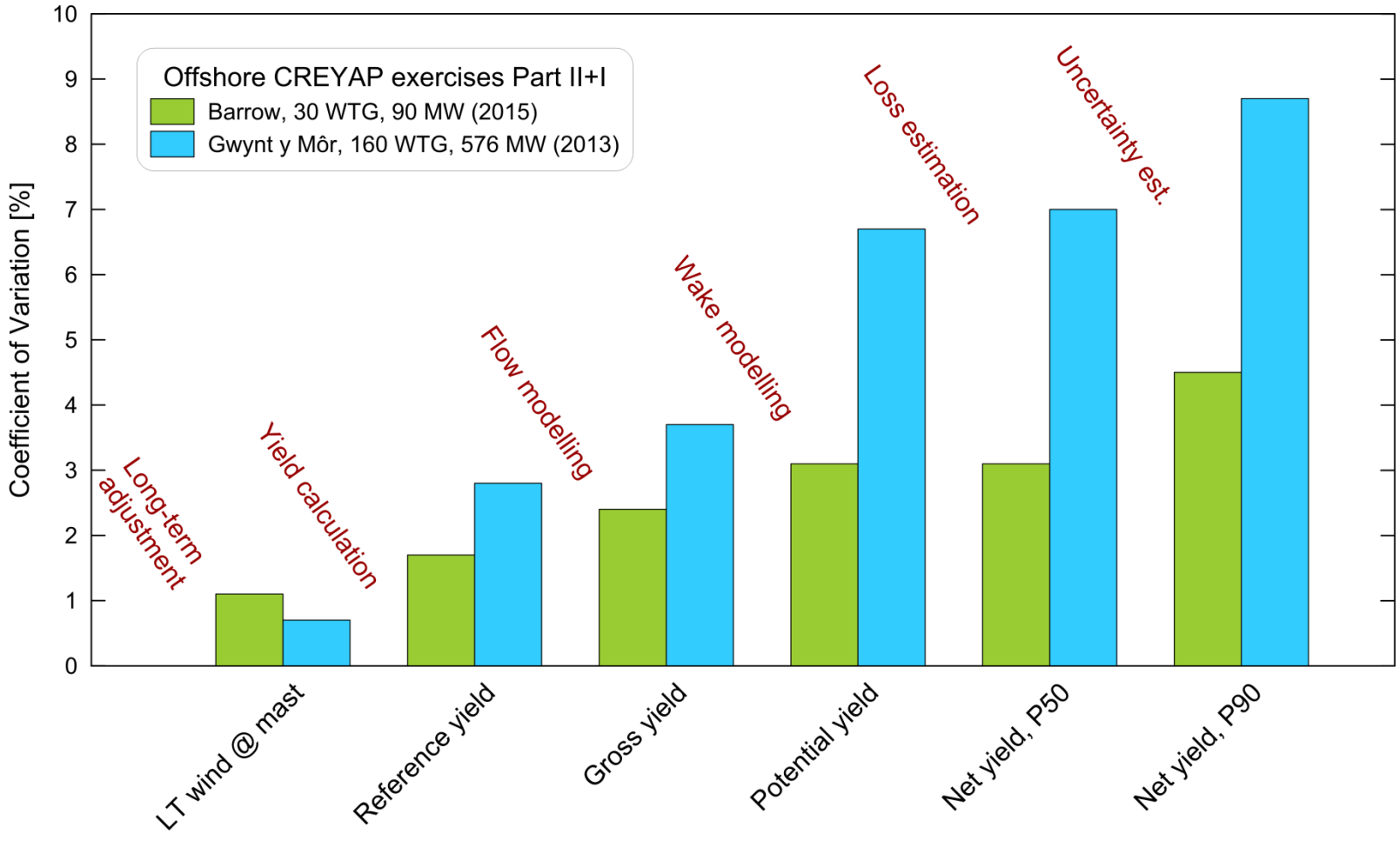


Wake modelling uncertainty (CREYAP 1-4, Nygaard 2015)

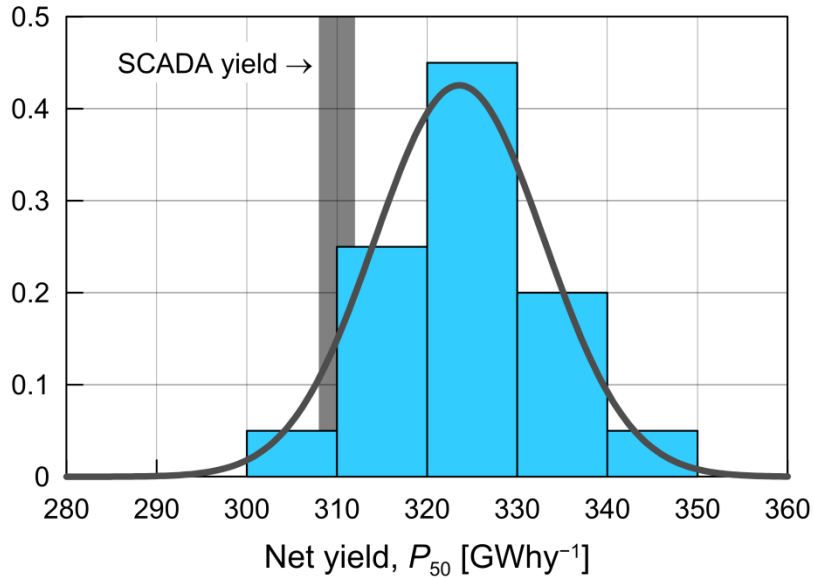
Wind farm	Size	Layout	Wake loss	Uncertainty
Onshore 1 Hilly	28 MW 14 WTG	Irregular 3.7-4.8 *D*	6.1%	13%
Onshore 2 Complex	29 MW 22 WTG	Irregular 4-5 *D*	10.3%	18%
Offshore 1† Gwynt y Môr	576 MW 160 WTG	Regular 6-7 *D*	14.3%	22%
Offshore 2 Barrow	90 MW 30 WTG	4 staggered 5.5×8.5 *D*	7.9%	16%
10 offshore‡ DONG 2015	90-630 MW 30-175 WTG	10 layouts	one model	16%

† Without two rather unusual outliers
‡ N.G. Nygaard, EWEA Offshore 2015

Uncertainty for offshore wind farm predictions



Barrow predicted vs observed P_{50} (1 year)



Data points used = 20 (of 22)

Mean predicted P_{50} = 324 GWhy^{-1}

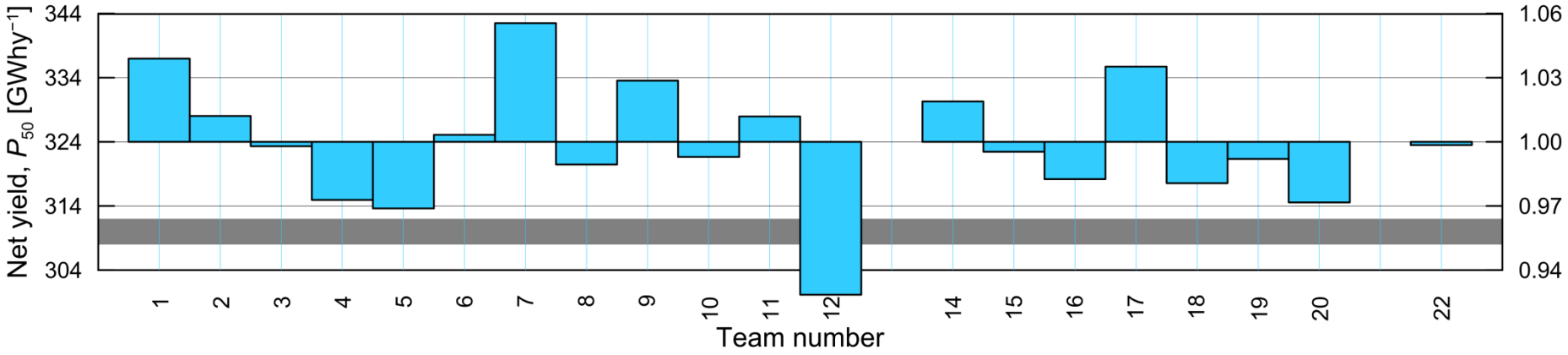
Standard deviation = 9.6 GWhy^{-1}

Coefficient of variation = 3.0%

Range = 300 to 343 GWhy^{-1}

Prediction bias = +4%

(cf. Cox, EWEA Offshore 2015)



Summary and conclusions – offshore wind farms

- Important issues offshore
  - Yield calculations
  - Wake modelling
  - Technical losses
  - Uncertainty estimation
- Wake modelling
  - Represent a significant loss
  - Uncertainty $\propto$ WTG wake loss
  - Models and spec's important
  - Configuration essential too!
  - Classic models seem to provide realistic results for Barrow
  - Many more farms necessary…
- Yield assessment uncertainties
  - About 5-9% (minimum)
  - Consistent self-evaluation
- Modelled vs observed yields
  - Data for Barrow only
  - Estimated = 104% of obs. AEP
  - Spread (uncertainty) = 3%
- Standards and guidelines
  - Vocabulary and definitions
  - Best practice calculations and reporting
  - IEC, IEA, Measnet, …
- 'Human factor' largely unknown


Thank you for your attention!
Handouts and papers from CREYAP exercises available from DTU web site

CREYAP references

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